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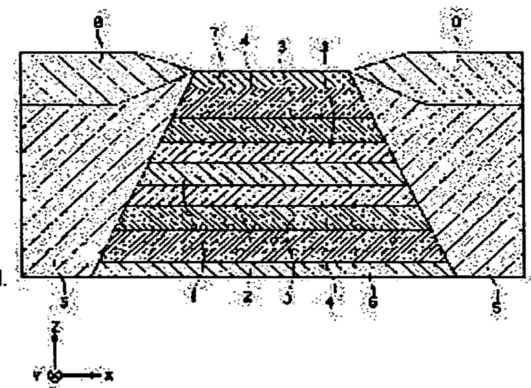
(54) DUAL SPIN BULB-TYPE THIN FILM MAGNETIC HEAD

(57)Abstract:
PROBLEM TO BE SOLVED: To produce a dual spin bulb-type thin film magnetic head having good characteristics as a thin film magnetic head by using a PtMn alloy layer or a PdMn alloy or Pt-Mn-X alloy (wherein X is Ni, Pd, Rh, etc.,) having almost the same properties as those of PtMn to form an antiferromagnetic layer.
SOLUTION: The antiferromagnetic layer 4 is formed by using a PtMn alloy or a PdMn alloy or Pt-Mn-X alloy (wherein X is Ni, Pd, Rh, Ru, Ir, Cr, Fe and Co) having almost the same properties as those of PtMn. Thereby, a dual spin bulb-type thin film magnetic head can be obtd. and in this head, an effective exchange anisotropic magnetic field can be obtd. without depending whether the antiferromagnetic layer 4 is formed on or under a spin magnetic layer 3. By this method, the temp. of heat treatment to generate exchange coupling by the antiferromagnetic film 4 can be decreased. The obtd. dual spin bulb-type thin film magnetic head has such properties that diffusion on the interfaces between a nonmagnetic conductive layer 2 and a free magnetic layer 1 or the spin magnetic layer 3 can be prevented and a high change rate of resistance can be obtd.



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CLAIMS

[Claim(s)]
[Claim 1] The nonmagnetic conductive layer to which the laminating of the free magnetic layer was carried out up and down, and the pin magnetic layer located on said one nonmagnetic conductive layer and under the nonmagnetic conductive layer of another side, The antiferromagnetism layer which is located on said one pin magnetic layer and under the pin magnetic layer of another side, and fixes the magnetization direction of each pin magnetic layer in the fixed direction by the exchange anisotropy field, The dual spin bulb mold thin film magnetic head characterized by having the bias layer which arranges the magnetization direction of said free magnetic layer in the magnetization direction of said pin magnetic layer, and the crossing direction, and forming said antiferromagnetism layer with the PtMn (platinum-manganese) alloy.
[Claim 2] The dual spin bulb mold thin film magnetic head according to claim 1 in which said free magnetic layer and said pin magnetic layer are formed with a FeNi (iron-nickel) alloy or Co (cobalt), the Fe-Co alloy, and the Fe-Co-nickel alloy.
[Claim 3] The film presentation of said PtMn alloy is the dual spin bulb mold thin film magnetic head according to claim 1 or 2 whose Pt is 44 to 51 atom % and whose Mn is the range of 49 - 56 atom %.
[Claim 4] The dual spin bulb mold thin film magnetic head according to claim 1 in which an antiferromagnetism layer replaces with a PtMn alloy and is formed with a Pt-Mn-X (X=nickel, Pd, Rh, Ru, Ir, Cr, Fe, Co) alloy or a PdMn alloy.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the so-called spin bulb mold thin film magnetic head from which electric resistance changes by the relation between the direction of magnetization of a pin (Pinned) magnetic layer, and the direction of the magnetization of a free (Free) magnetic layer influenced of an external magnetic field, and relates to the dual spin bulb mold thin film magnetic head by which the laminating of the antiferromagnetism layer is carried out to each of a pin magnetic layer in which a free magnetic layer is located up and down.
[0002]
[Description of the Prior Art] There is a GMR (Giant Magnetoresistive) head using the component which shows MR (Magnetoresistive) head using the component which shows a magneto-resistive effect, and giant magneto-resistance among the magneto-resistive effect mold reading heads. The magnetic substance which said MR head shows a magneto-resistive effect has monolayer structure. On the other hand, the GMR head is formed by the multilayer structure with which the layer which shows a magneto-resistive effect combined two or more ingredients. Although there are some classes of the structures which produce giant magneto-resistance, structure is comparatively simple in it and a spin bulb method is one of those have high resistance rate of change to an external magnetic field. There are a single spin bulb method and a dual spin bulb method as spin bulb method.
[0003] Drawing 8 shows the single spin bulb mold thin film magnetic head, and consists of the bottoms at four layers, the free (Free) magnetic layer 1, the nonmagnetic conductive layer 2, the pin (Pinned) magnetic layer 3, and the antiferromagnetism layer 4. Moreover, the signs 5 and 5 located in both sides are hard bias layers. 6 and 7 are the substrate layers and protective layers which were formed by non-magnetic materials, such as Ta (tantalum), and 8 is a conductive layer. The coercive force of said pin magnetic layer 3 is highly set up compared with the coercive force of the free magnetic layer 1. The pin magnetic layer 3 and the antiferromagnetism layer 4 touch, and are formed, said pin magnetic layer 3 is single-domain-ized in the direction of Y by the exchange anisotropy field by the switched connection in an interface with said antiferromagnetism layer 4, and the direction of magnetization is fixed in the direction of Y. Said exchange anisotropy field is produced in the interface of said antiferromagnetism layer 4 and said pin magnetic layer 3 by heat-treating giving a field.
[0004] Moreover, it is influenced of the hard bias layer 5 magnetized in the direction of X, and the magnetization direction of said free magnetic layer 1 is arranged in the direction of X. Generating of a Barkhausen noise can be prevented by single-domain-izing the free magnetic layer 1 in the predetermined direction by the hard bias layer 5. In this single spin bulb mold thin film magnetic head, the stationary current is given to the free magnetic layer 1, the nonmagnetic conductive layer 2, and the pin magnetic layer 3 from a conductive layer 8. The transit direction of magnetic-recording media, such as a hard disk, is a Z direction, and if the leak field from said magnetic-recording medium is given in the direction of Y, the direction of magnetization of the free magnetic layer 1 will change from X towards the direction of Y. Electric resistance changes by the relation between fluctuation of the direction of magnetization within this free magnetic layer 1, and the fixed magnetization direction of the pin magnetic layer 3, and the leak field from a magnetic-recording medium is detected by the electrical-potential-difference change based on this electric resistance value change.
[0005] Next, drawing 1 is the sectional view showing the dual spin bulb mold thin film magnetic head. In the dual spin bulb mold, the laminating of the nonmagnetic conductive layers 2 and 2, the pin magnetic layers 3 and 3, and the antiferromagnetism layers 4 and 4 is carried out to the candidate for vertical the core [the free magnetic layer 1]. the switched connection the direction of magnetization of said free magnetic layer 1 is arranged in the direction of X by the hard bias layer 5, and according [said pin magnetic layer 3 and the direction of magnetization of three] to the exchange anisotropy field in the interface of said pin magnetic layers 3 and 3 and antiferromagnetism layers 4 and 4 — it is — the direction of Y — a single domain — it is-izing and fixed.
[0006] When the magnetization direction of said free magnetic layer 1 changes from X towards the direction of Y, an electric resistance value changes with the leak fields of the direction of Y from said record medium. In the thin film magnetic head of a spin bulb mold, if the magnetization direction of the free magnetic layer 1 changes from X towards the direction of Y The electron which is going to move to the layer of another side from layer of one of the two between the free magnetic layer 1 and the pin magnetic layer 3 By causing dispersion by the interface of the nonmagnetic conductive layer 2 and the free magnetic layer 1, or the interface of the nonmagnetic conductive layer 2 and the pin magnetic layer 3, electric resistance changes and the leak field from a magnetic-recording medium is detected by the electrical-potential-difference change based on this electric resistance value change.

[0007] When the include angle of the direction of magnetization of the free magnetic layer 1 and the direction of magnetization of the pin magnetic layer 3 becomes the largest (i.e., when it becomes anti-parallel), said electric resistance shows maximum, and as for said electric resistance, the minimum value is shown when the direction of magnetization of said free magnetic layer 1 and the direction of magnetization of said pin magnetic layer 3 become the same. When the leak field from a record medium is given, as resistance rate of change {(the maximum electrical-potential-difference value-minimum electrical-potential-difference value) the /minimum electrical-potential-difference value} becomes large, the property of the thin film magnetic head becomes better.
[0008] In the single spin bulb mold thin film magnetic head shown in drawing 8 The location where electronic dispersion takes place The interface of the nonmagnetic conductive layer 2 and the free magnetic layer 1, and by the dual spin bulb mold thin film magnetic head shown in drawing 1 , to being two places of the interface of the nonmagnetic conductive layer 2 and the pin magnetic layer 3 Since the location where electronic dispersion takes place is a total of four places of two interfaces of the nonmagnetic conductive layer 2 and the free magnetic layer 1, and two interfaces of the nonmagnetic conductive layer 2 and the pin magnetic layer 3, Compared with the single spin bulb mold thin film magnetic head, resistance rate of change becomes [the direction of the dual spin bulb mold thin film magnetic head] large.
[0009]
[Problem(s) to be Solved by the Invention] Generally as said free magnetic layer 1 and a pin magnetic layer 3, Cu (copper) film is used as the FeNi (iron-nickel) system alloy film and a nonmagnetic conductive layer 2. Moreover, generally in the conventional single spin bulb mold thin film magnetic head shown in drawing 8 , the FeMn (iron-manganese) alloy film is used as an antiferromagnetism ingredient which constitutes the antiferromagnetism layer 4. However, it is easy to corrode, and when said FeMn film is exposed into the air containing moisture, it has the fault which generates **** quickly. Moreover, the blocking temperature in the switched connection of the FeMn alloy film of an antiferromagnetism ingredient and the FeNi alloy film which is a pin magnetic layer has the fault to which an exchange anisotropy field becomes weak and the noise in a detection output becomes large, when it is as low as about 150 degrees C and the temperature of a head becomes high with self-generation of heat or environmental temperature during thin film magnetic-head actuation.
[0010] Moreover, there are IrMn (iridium-manganese) alloy film, RhMn (rhodium-manganese) alloy film, etc. as an antiferromagnetism ingredient which replaces said FeMn alloy. However, said FeMn (iron-manganese) alloy film, the IrMn (iridium-manganese) alloy film, the RhMn (rhodium-manganese) alloy film, etc. Although switched connection can be demonstrated in an interface with the pin magnetic layer 3 when membranes are formed in piles on ferromagnetic ingredients, such as a FeNi alloy which constitutes the pin magnetic layer 3 Since it has the description with which these antiferromagnetism ingredients tend to receive the effect of a substrate layer, and near the top face of an antiferromagnetism ingredient is hard to demonstrate the property of antiferromagnetism, when the pin magnetic layer 3 piles up and is formed on an antiferromagnetism ingredient, it has the property in which switched connection cannot be demonstrated.
[0011] Thus, the antiferromagnetism ingredient listed above can demonstrate effective switched connection, only when a laminating is carried out to one side of the upper bottom to the pin magnetic layer 3. Therefore, with the structure where the antiferromagnetism layers 4 and 4 are formed by the both sides of the pin magnetic layer 3 and 3 top and the bottom, said antiferromagnetism ingredient cannot be used like the dual spin bulb mold shown in drawing 1 . moreover, the pin magnetic layer 3 -- receiving -- the upper and lower sides -- whichever it is formed in, there is a NiMn (nickel-manganese) alloy as an ingredient which can acquire an exchange anisotropy field. Since this antiferromagnetism ingredient can be formed to the both sides of the pin magnetic layer 3 top and the bottom, it is usable to the dual spin bulb mold thin film magnetic head shown in drawing 1 .
[0012] However, in order to demonstrate effective switched connection between this NiMn alloy film and the FeNi system alloy film (pin magnetic layer 3), heat-treatment (annealing) at comparatively high temperature is needed. That is, the antiferromagnetism layer 4 is the NiMn alloy film, and when the pin magnetic layer 3 is a FeNi system alloy, the quite high temperature of about 250 degrees C or more is required [in order to generate an exchange anisotropy field, after joining the antiferromagnetism layer 4 and the pin magnetic layer 3 and forming membranes, it is required to give a field and to heat-treat, but] for the heat treatment temperature for demonstrating effective exchange anisotropy association. However, if hot heat treatment of 250 degrees C or more is performed, it will set to the interface of the free magnetic layer 1 and the pin magnetic layer 3 which are formed by the FeNi alloy film, and the nonmagnetic conductive layer 2 currently formed by Cu. Diffusion of a metallic element occurs, the magneto-resistive effect by the electronic diffusion by the interface of the free magnetic layer 1 and the nonmagnetic conductive layer 2 and the interface of the pin magnetic layer 3 and the nonmagnetic conductive layer 2 is affected, and there is a problem to which the resistance rate of change to an external magnetic field falls.
[0013] this invention being for solving the above-mentioned conventional technical problem, and forming an antiferromagnetism layer with a PtMn (platinum-manganese) alloy etc. -- said antiferromagnetism layer -- the upper and lower sides of a pin magnetic layer -- whichever it is formed in, it aims at offering the dual spin bulb mold thin film magnetic head which can acquire an effective exchange anisotropy field.
[0014] Moreover, as this invention can make low heat treatment temperature for demonstrating the switched connection by the antiferromagnetism film, it can prevent diffusion by the interface of a free magnetic layer and a pin magnetic layer, and a nonmagnetic conductive layer, and it aims at offering the dual spin bulb mold thin film magnetic head which can obtain high resistance rate of change.
[0015]

[Means for Solving the Problem] The dual spin bulb mold thin film magnetic head of this invention The nonmagnetic conductive layer to which the laminating of the free magnetic layer was carried out up and down, and the pin magnetic layer located on said one nonmagnetic conductive layer and under the nonmagnetic conductive layer of another side, The antiferromagnetism layer which is located on said one pin magnetic layer and under the pin magnetic layer of another side, and fixes the magnetization direction of each pin magnetic layer in the fixed direction by the exchange anisotropy field, It has the bias layer which arranges the magnetization direction of said free magnetic layer in the magnetization direction of said pin magnetic layer, and the crossing direction, and is characterized by forming said antiferromagnetism layer with the PtMn (platinum-manganese) alloy.
[0016] In the above, said free magnetic layer and said pin magnetic layer are formed for example, with a FeNi (iron-nickel) system alloy.
[0017] Moreover, Pt is 44 to 51 atom %, and, as for the film presentation of said PtMn alloy, it is desirable that Mn is the range of 49 - 56 atom %.
[0018] Furthermore, it is also possible to replace an antiferromagnetism layer with a PtMn alloy and to form it with a Pt-Mn-X (X=nickel, Pd, Rh, Ru, Ir, Cr, Fe, Co) alloy or a PdMn alloy.
[0019] Moreover, it is also possible to form said free magnetic layer and said pin magnetic layer with Co (cobalt), a Fe-Co (iron-cobalt) alloy, and a Fe-Co-nickel (iron-cobalt-nickel) alloy.
[0020] In this invention, the PtMn alloy film or the PdMn alloy film of a property equivalent to this is used as an antiferromagnetism ingredient which constitutes an antiferromagnetism layer. Whichever it puts [of the ferromagnetic ingredient top which constitutes a pin magnetic layer, and the bottom] these antiferromagnetism ingredients, they can demonstrate an effective exchange anisotropy field by the interface with a pin magnetic layer. Therefore, when the dual spin bulb mold thin film magnetic head by which a pin magnetic layer is prepared in the vertical position of symmetry of a free magnetic layer, and an antiferromagnetism layer is prepared in the bottom of the pin magnetic layer of another side one pin magnetic layer top is constituted using said antiferromagnetism ingredient, sufficient magneto-resistive effect can be acquired.
[0021] Moreover, if the PtMn alloy film or the PdMn alloy film is used as said antiferromagnetism layer, exchange anisotropy field with the heat treatment temperature sufficient [at least 230 degrees C or less] after membrane formation can be acquired. Therefore, in said heat treatment, diffusion by the interface of a nonmagnetic conductive layer, and a pin magnetic layer and a free magnetic layer can be prevented, and high resistance rate of change can be obtained to an external magnetic field.
[0022] Moreover, the PtMn alloy film is excellent in corrosion resistance compared with the FeMn alloy film or the NiMn alloy film, and also in various kinds of solvents and cleaning agents in a dual spin bulb mold thin film magnetic-head production process, corrosion did not advance at all but it is chemically stable [corrosion] also in actuation of the dual spin bulb mold thin film magnetic head under a harsh environment.
[0023] Furthermore, even if it is very stable thermally, blocking temperature is high at about 380 degrees C and the temperature at the time of actuation of the thin film magnetic head therefore becomes high, the exchange anisotropy field acquired when the PtMn alloy film and a pin magnetic layer touched can generate the stable exchange anisotropy field, and the accuracy of reading is stabilized.
[0024]
[Embodiment of the Invention] Drawing 1 is the sectional view showing the structure of the dual spin bulb mold thin film magnetic head of this invention. This thin film magnetic head is prepared in the trailing side edge section of the surfacing type slider formed in a hard disk drive unit etc., the migration direction of magnetic-recording media, such as a hard disk, is a Z direction, and the direction of the leak field from a magnetic-recording medium is the direction of Y.
[0025] The substrate layer 6 formed by non-magnetic materials, such as Ta (tantalum), is formed in the bottom of drawing 1 . The laminating of the antiferromagnetism layer 4 formed with the PtMn (platinum-manganese) alloy on this substrate layer 6 and the pin magnetic layer 3 formed with the FeNi (iron-nickel) system alloy is carried out. On said pin magnetic layer 3, the nonmagnetic conductive layers 2, such as Cu (copper), are formed, and the free magnetic layer 1 of a FeNi system alloy is formed on said nonmagnetic conductive layer 2. Furthermore, on said free magnetic layer 1, the nonmagnetic conductive layer 2, the pin magnetic layer 3, and the antiferromagnetism layer 4 continue, a laminating is carried out and the protective layers 7, such as Ta, are formed further.
[0026] an exchange anisotropy field obtains by the interface of said both layers by heat-treating in the field of predetermined magnitude, where the laminating of said antiferromagnetism layer 4 and pin magnetic layer 3 is carried out — having — the direction of magnetization of said pin magnetic layer — the direction of Y — a single domain — it is-izing and fixed. When the antiferromagnetism layer 4 is formed with a PtMn alloy and the pin magnetic layer 3 is formed with a FeNi system alloy, in the time of the antiferromagnetism layer 4 being formed in the bottom of the pin magnetic layer 3, and the both sides when being formed on the antiferromagnetism layer 4, switched connection becomes possible. In addition, even if it forms said pin magnetic layer 3 with Co (cobalt), a Fe-Co (iron-cobalt) alloy, and a Fe-Co-nickel (iron-cobalt-nickel) alloy, an exchange anisotropy field can be acquired by the interface with the antiferromagnetism layer 4.
[0027] After membranes are formed by the spatter and the multilayers from the substrate layer 6 to a protective layer 7 are etched into a predetermined cross-section configuration, the hard bias layer 5 which gives a bias field to said free magnetic layer 1 is formed. Said hard bias layer 5 is magnetized in the direction of X, and magnetization of the free magnetic layer 1 is arranged in the direction of X. Moreover, the conductive layers 8 and 8 formed of W (tungsten), Cu (copper), etc. on the hard bias layers 5 and 5 are formed.

[0028] Thus, in the formed dual spin bulb mold thin film magnetic head, if the stationary current is given to the free magnetic layer 1, the nonmagnetic conductive layer 2, and the pin magnetic layer 3 from a conductive layer 8 and a field is moreover given in the direction of Y from a record medium, the direction of magnetization of the free magnetic layer 1 will change from X towards the direction of Y. At this time, the electron which is going to move to another side starts dispersion from layer of one of the two among the free magnetic layer 1 and the pin magnetic layer 3 by the interface of the nonmagnetic conductive layer 2 and the free magnetic layer 1, or the interface of the nonmagnetic conductive layer 2 and the pin magnetic layer 3, and electric resistance changes. Therefore, the stationary current can change and a detection output can be obtained. The PtMn alloy used for the antiferromagnetism layer 4 by this invention is excellent in corrosion resistance compared with the FeMn (iron-manganese) alloy or the NiMn (nickel-manganese) alloy. Therefore, degradation of the head property by corrosion can be prevented.
[0029]
[Example] The example of the multilayers which used the PtMn alloy film as an antiferromagnetism layer below, and the dual spin bulb mold thin film magnetic head which used these multilayers is explained. The component width of face (width of recording track) of the direction of X formed the dual spin bulb component (drawing 1) and single spin bulb component (drawing 8) whose component die length (MR height) of 2.2 micrometers and the direction of Y is 1.5 micrometers.
[0030] The film configuration of a dual spin bulb component forms an alumina (aluminum 2O3) as a non-magnetic material on a silicon (Si) substrate. Membranes are formed in order of a protective layer 7 from the substrate layer 6 like drawing 1 on it. The configuration film ingredient They are Ta(3nm)/PtMn(20nm)/NiFe(4nm)/Cu(2.5nm)/NiFe (7nm)/Cu(2.5nm)/NiFe(4nm)/PtMn (20nm) / Ta (5nm). In addition, the inside of a parenthesis is thickness. The film configuration of a single spin bulb component forms the film of an alumina on a silicon substrate. Moreover the layer of drawing 8 and vertical reverse is formed, and it is the order of a magnetic layer / pin magnetic layer / nonmagnetic conductive layer / free magnetic layer / protective layer the anti-[a substrate layer /] strength from the bottom. As a concrete ingredient It was referred to as Ta (3nm)/PtMn(30nm)/NiFe(4nm)/Cu(2.5nm)/NiFe (8nm) / Ta (5nm) from the bottom.
[0031] Moreover, Pt made it as 48 atoms % (at%), and Mn made the film presentation of the dual spin bulb film and the PtMn film which serves as an antiferromagnetism layer in the both sides of the single spin bulb film the thing of 52 atom % (at%) (Pt48Mn52). DC magnetron sputtering performed the above-mentioned membrane formation using the alloy target. In said dual spin bulb component, the switched connection field (Hex) given to the FeNi alloy film of the pin magnetic layer 3 from the PtMn alloy film which is the antiferromagnetism layer 4 was [the coercive force (Hc) of 470 (Oe) and the pin magnetic layer 3] 240 (Oe) by performing 230-degree C heat treatment.
[0032] Moreover, as shown in drawing 1 and drawing 8 , on both sides of said dual spin bulb component, the CoPt alloy film with a thickness of 30nm was formed as a hard bias layer 5, and said CoPt alloy film was formed in 20nm in thickness as a hard bias layer 5 on both sides of a single spin bulb component. Moreover, remnant magnetism (Mr) was 0.9T (tesla), and the coercive force of said hard bias layer 5 was 1300 (Oe). Moreover, when said multilayers were formed on a 5mmx25mm silicon substrate, for sheet resistance, with said dual spin bulb component, resistance rate of change was [resistance rate of change / sheet resistance] 16.3 ohm/m 2 3.9% in 10.8 ohm/m 2 and said single spin bulb component 6.2%.
[0033] The resistance rate of change of a dual spin bulb component is high compared with the resistance rate of change of a single spin bulb component as mentioned above. The antiferromagnetism layer 4 of the PtMn alloy with which both the pin magnetic layers 3 and 3 by which this is formed in the both sides of the free magnetic layer 1 top and the bottom meant that magnetization was being fixed in the direction of Y, and this was formed in the pin magnetic layer 3 bottom, The both sides of the antiferromagnetism layer 4 of the PtMn alloy formed in the pin magnetic layer 3 bottom mean demonstrating switched connection by the interface with the pin magnetic layers 3 and 3. Next, to the dual spin bulb component and single spin bulb component whose component width of face (width of recording track Tw) is 2.2 micrometers and whose component die length (MR height h) is 1.5 micrometers, the 5mA stationary current (Is) was given, the external magnetic field was given from Y, this external magnetic field was changed, and change (it is proportional to resistance change) of an electrical potential difference was measured from the stationary current Is.
[0034] Drawing 2 takes the magnitude of an external magnetic field along an axis of abscissa, the change (deltaV) of an electrical potential difference based on the stationary current given to the axis of ordinate at the dual spin bulb component is taken, (A) is the major loop formation which took change in the range of **2K(Oe) of an external magnetic field along the axis of abscissa, and (B) is the minor loop which took change in the range of **200 (Oe) of an external magnetic field along the axis of abscissa.
[0035] From the major loop formation of drawing 2 (A), electrical-potential-difference change of a dual spin bulb component was 4.4mV, and resistance rate of change was 3.5%. Moreover, the major loop formation is drawing the smooth curve and has not become two-step change. It is shown that the two-layer pin magnetic layers 3 and 3 are single-domain-ized by the exchange anisotropy field of almost equal magnitude, and this has almost equal coercive force. Moreover, even if there is no hysteresis in a minor loop and it returns an external magnetic field to 0 (Oe), it turns out that the coercive force of said free magnetic layer is zero mostly. That is, it is shown that single domain-ization to the direction of X of the free magnetic layer 1 is made by the hard bias layer 5, and the Barkhausen noise can be reduced.
[0036] Drawing 3 is the result of measuring fluctuation of the electrical-potential-difference rate of change

(resistance rate of change) (deltaV/V) when changing the stationary current (Is) in **10mA about the both sides of a single spin bulb component and a dual spin bulb component. The direction where the field according [said stationary current / on a single spin bulb component and] to this stationary current weakens the exchange anisotropy field of a pin magnetic layer is considered as plus. In drawing 3 , the resistance rate of change of a dual spin bulb component is larger than the resistance rate of change of a single spin bulb component irrespective of change of the stationary current. Furthermore, to 1mA deltaV/V, rate-of-change deltaV/V in case the stationary current is 10mA is 8.8% of reduction with a dual spin bulb component, and serves as 16.2% of reduction with the single spin bulb component. Drawing 3 shows that the resistance rate of change in the dual spin bulb component of this invention is stable to change of the stationary current.

[0037] Drawing 4 is the graph which showed change of the stationary current, and relation with asymmetry (Asymmetry). In drawing 4 , it asks from a minor loop and the symmetric property of the electrical-potential-difference change (resistance change) by **40 (Oe) equivalent to the magnitude of the leak field from magnetic-recording media, such as a hard disk, is investigated. An axis of abscissa shows change of the stationary current, and the axis of ordinate shows the asymmetry of the both sides of a dual spin bulb component and a single spin bulb component by (deltaV(-40Oe)-deltaV(+40Oe))/(deltaV(-40Oe) +deltaV (+40Oe)).

[0038] At drawing 4 , the asymmetry of a dual spin bulb component is abbreviation. - It is 10% and it turns out that there is almost no dependency over the stationary current. On the other hand, at a single spin bulb component, it is abbreviation. - It turns out that it is changing from 32% to +1%, and depends to the stationary current strongly. It is for the dual spin bulb component to change with the film configuration for the upper and lower sides, for the stationary current field from which the flowing stationary current makes the upper and lower sides of a free magnetic layer to negate this mutually within a free magnetic layer, and for a stationary current field not to act on a free magnetic layer.

[0039] As mentioned above, the dual spin bulb component using the PtMn alloy as an antiferromagnetism layer 4 can obtain big resistance rate of change to an external magnetic field, and, moreover, there is no hysteresis in this resistance rate of change, and it cannot be influenced by the stationary current further easily of change. Therefore, the dual spin bulb mold thin film magnetic head which used the PtMn alloy as the antiferromagnetism layer can acquire the outstanding property.

[0040] Next, the experimental result about the switched connection of the PtMn alloy which forms the antiferromagnetism layer 4, and the ferromagnetic ingredient which forms the pin magnetic layer 3 is explained. First, by DC magnetron sputtering and RF conventional spatter, the alumina was formed on the front face of a silicon (Si) substrate, Ta (3nm)/FeNi(5nm)/PtMn (20nm) / Ta (5nm) was further formed sequentially from the bottom, and it covered with the alumina further. The inside of the aforementioned parenthesis is thickness.

[0041] Membrane formation of the PtMn film is performed at Mn target using the multicomponent target and alloy target which have arranged Pt chip, and enabled it to change the presentation of PtMn at the time of membrane formation into it. Although the presentation of the PtMn film was changed, the PtMn film of 1 micrometer of thickness is formed on Si substrate at said multilayers and coincidence, and it enabled it for XMA (electron probe X-ray microanalyser) to analyze the film presentation of PtMn in the multilayers of said configuration. In said multilayers, heat treatment for obtaining the switched connection between the PtMn alloy of an antiferromagnetism ingredient and the FeNi alloy of a ferromagnetic ingredient is the degree of vacuum of 5x10 to 6 or less Torrs, and the temperature of 270 degrees C performed it in the field of 2000 (Oe). VSM with a vacuum heating device performed measurement of an exchange anisotropy field (Hex).

[0042] Drawing 5 shows the measured value of an exchange anisotropy field (Hex), after heat-treating the film presentation of the PtMn film at 270 degrees C as mentioned above with the condition immediately after membrane formation at the time of making it change so that Pt may serve as the range of 0 - 60at% (as depo.). In the both sides when not carrying out, when it heat-treats, as shown in drawing 5 , although Hex arises [Pt] in 0 - 25at%, when it is generated only when the laminating of the PtMn film is carried out on the NiFe film, and, as for this switched connection, the PtMn film is formed in the bottom of the FeNi film, switched connection is not produced.

[0043] The range of Pt is 42at(s)% to 55at(s)%, and after heat treatment produces switched connection and produces switched connection in both sides when membranes are formed in the time of the PtMn film being formed on the FeNi film in this case, and the bottom. And in 44 - 51at%, an exchange anisotropy field (Hex) exceeds [Pt] 130 (Oe), and said Hex exceeds [Pt] 240 (Oe) in 46 - 49at%. Therefore, it is desirable still more desirable that Pt is [Mn] 49 - 56at% in the range of 44 - 51at%, and Pt is [Mn of the presentation of the PtMn alloy which is made to generate an exchange anisotropy field by heat treatment, and constitutes an antiferromagnetism layer from the dual spin bulb mold thin film magnetic head shown in drawing 1] 51 - 54at% at 46 - 49at%.

[0044] Drawing 6 measures the switched connection of the PtMn film which is an antiferromagnetism ingredient, and the FeNi film used as a pin magnetic layer, and relation with heat treatment temperature. The film configuration formed the alumina layer on the silicon substrate, and formed membranes on it in order of Ta (3nm)/PtMn (30nm)/FeNi/Ta (5nm) / alumina. DC magnetron sputtering performed the film using the alloy target. Moreover, Mn made [Pt] the presentation of the PtMn film 52at(s)% at 48at(s)%. Moreover, the thickness of the FeNi film could be five kinds, 2nm, 3nm, 4nm, 10nm, and 20nm.

[0045] The exchange anisotropy field (Hex) was generated in the field of 2000 (Oe) about each above-mentioned multilayers in the degree of vacuum of 5x10 to 6 or less Torrs. Heat-treatment in said vacuum was made into 0 degree C, 190 degrees C, 210 degrees C, 230 degrees C, and 250 degrees C. The exchange anisotropy field was measured by VSM per [which was heat-treated at each temperature] multilayers. In drawing 6 , change of the

thickness of the FeNi film was taken along the axis of abscissa, and the exchange anisotropy field (Hex) is taken along the axis of ordinate.
[0046] if the exchange anisotropy field (Hex) more than 200 (Oe) can be acquired by 210-degree C heat treatment if the thickness of the FeNi film which serves as a pin magnetic layer according to drawing 6 is 5nm or less, and the thickness of the FeNi film is 10nm or less, heat treatment temperature is about 230 degrees C -- in low temperature, an exchange anisotropy field is comparatively made more than 200 (Oe). That is, if PtMn is used as an antiferromagnetism layer 4, an exchange anisotropy field can be generated in heat treatment at comparatively low temperature, it becomes possible to prevent diffusion with the NiFe film as Cu film, pin magnetic layer, or free magnetic layer as a nonmagnetic conductive layer which poses a problem by hot heat treatment, and the property as the always good thin film magnetic head can be acquired.
[0047] Drawing 7 investigates as a pinching nature ingredient which constitutes the pin magnetic layer 3 about the effect of the environmental temperature of operation in the case where a FeNi alloy is used, and the case where Co is used. The film configuration manufactured what formed alumina / Ta (3nm) / PtMn(30nm)/FeNi (3nm) / Ta (5nm) / alumina on the silicon substrate, and two kinds of things which formed alumina / Ta (3nm) / PtMn (30nm)/Co (4nm) / Ta (5nm) / alumina on the silicon substrate.
[0048] DC magnetron sputtering performed membrane formation using the alloy target, Pt is 48at(s)% and Mn made the presentation of the PtMn film 52at(s)%. It heat-treats at 230 degrees C, and was made to generate an exchange anisotropy field (Hex) in the field of 2000 (Oe) to the two above-mentioned kinds of multilayers in the degree of vacuum of 5x10 to 6 or less Torrs. It cooled even to the room temperature after heat treatment. The environmental temperature of each of said multilayers was raised after cooling, and the exchange anisotropy field at that time was measured.
[0049] Environmental temperature is shown on an axis of abscissa by drawing 7 , and the exchange anisotropy field (Hex) is shown on the axis of ordinate. When the FeNi film is used as a ferromagnetic ingredient used as a pin magnetic layer, even if it raises Hex from a room temperature to about 200 degrees C, it seldom falls, but it begins to fall from about 240 degrees C, and disappears at about 380 degrees C (blocking temperature). When Co is used for a pin magnetic layer, as for about 120 degrees C, change is seldom in sight from a room temperature, but Hex begins to fall gradually from about 120 degree C or subsequent ones, and serves as blocking temperature at about 380 degrees C like the case of the FeNi film. Thus, the FeNi film and Co film show 380 degrees C and a very high value, and since Hex by the FeNi film and Co film shows the almost flat value in the range of the room temperature which may rise as operating temperature of the magneto-resistive effect film circumference especially to about 120 degrees C, the temperature (blocking temperature) to which Hex disappears can acquire the always stabilized exchange anisotropy field.
[0050]
[Effect of the Invention] By being formed with the PdMn alloy in which an antiferromagnetism layer has a PtMn alloy, or this and a property of the same kind, or a Pt-Mn-X (X=nickel, Pd, Rh, Ru, Ir, Cr, Fe, Co) alloy according to this invention explained in full detail above said antiferromagnetism layer -- the upper and lower sides of a pin magnetic layer -- whichever it is formed in, it becomes possible to acquire an exchange anisotropy field, and an exchange anisotropy field also with effective heat treatment of further comparatively low temperature can be acquired. Moreover, a PtMn alloy has high thermal stability and is excellent also in corrosion resistance. Therefore, manufacture of the dual spin bulb mold thin film magnetic head which has a property as the good thin film magnetic head is attained.
[0051] Moreover, the dual spin bulb mold thin film magnetic head in which the antiferromagnetism layer was formed with the PtMn alloy, the PdMn alloy, or the Pt-Mn-X (X=nickel, Pd, Rh, Ru, Ir, Cr, Fe, Co) alloy has high resistance rate of change compared with the single spin bulb mold thin film magnetic head, and its asymmetry also improves by leaps and bounds.
[0052] Moreover, since the ingredient of said antiferromagnetism layer of the upper and lower sides of a pin magnetic layer can be communalized by forming an antiferromagnetism layer with a PtMn alloy, a PdMn alloy, or a Pt-Mn-X (X=nickel, Pd, Rh, Ru, Ir, Cr, Fe, Co) alloy, the number of the sputtering targets at the time of membrane formation can be reduced, and manufacture becomes easy.

[Translation done.]

DESCRIPTION OF DRAWINGS

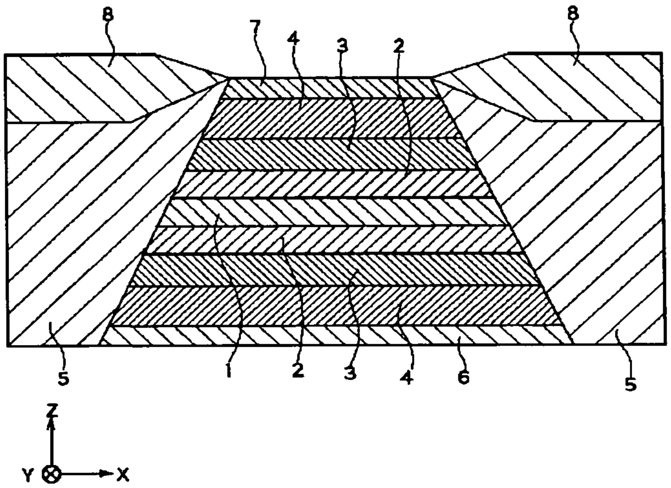
[Brief Description of the Drawings]
[Drawing 1] The expanded sectional view showing the structure of the dual spin bulb mold thin film magnetic head,
[Drawing 2] It is the diagram showing the relation of the external magnetic field and resistance rate of change in the dual spin bulb film, and for (A), it is a major loop formation and (B) is a minor loop,
[Drawing 3] The diagram showing the relation of the stationary current and the resistance rate of change in the single spin bulb film and the dual spin bulb film,
[Drawing 4] The diagram showing the relation of the stationary current and asymmetry in a single spin bulb component and a dual spin bulb component,
[Drawing 5] The diagram showing the relation of the film presentation and exchange anisotropy field of the PtMn film,
[Drawing 6] The diagram showing the relation between the thickness of heat treatment temperature and a pin magnetic layer (FeNi film), and an exchange anisotropy field,
[Drawing 7] The diagram showing the relation of the environmental temperature and the exchange anisotropy field at the time of using the FeNi film and Co film for a pin magnetic layer,
[Drawing 8] The expanded sectional view showing the structure of the single spin bulb mold thin film magnetic head,
[Description of Notations]
1 Free Magnetic Layer
2 Nonmagnetic Conductive Layer
3 Pin Magnetic Layer
4 Antiferromagnetism Layer
5 Hard Bias Layer
6 Substrate Layer
7 Protective Layer
8 Conductive Layer

[Translation done.]

DRAWINGS

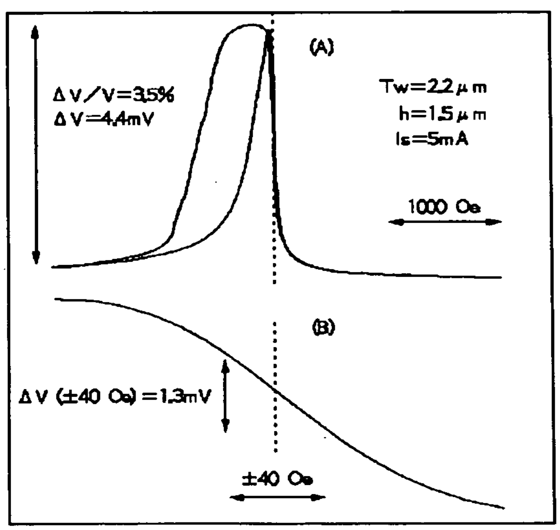
[Drawing 1]

図1



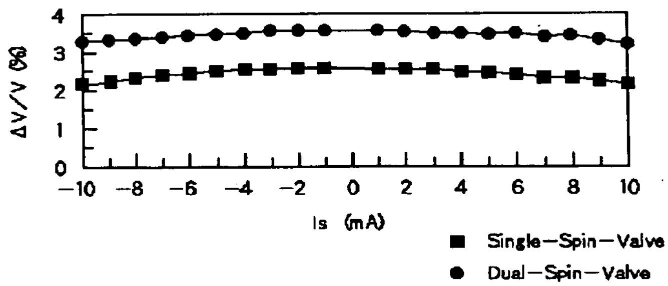
[Drawing 2]

図2



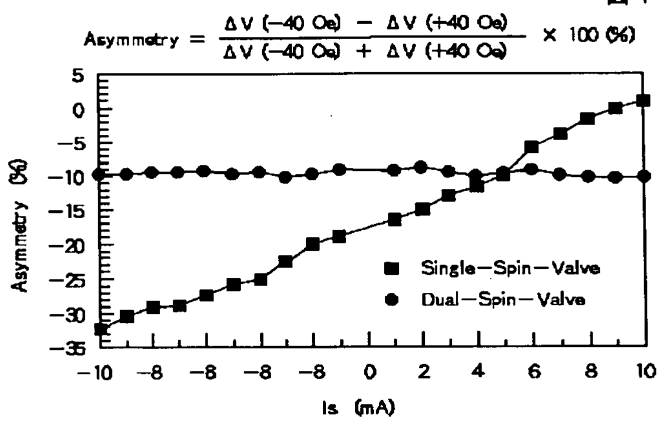
[Drawing 3]

図3



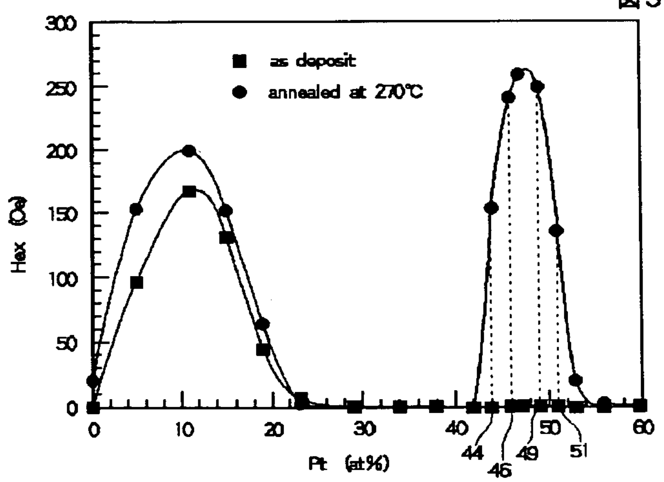
[Drawing 4]

図4



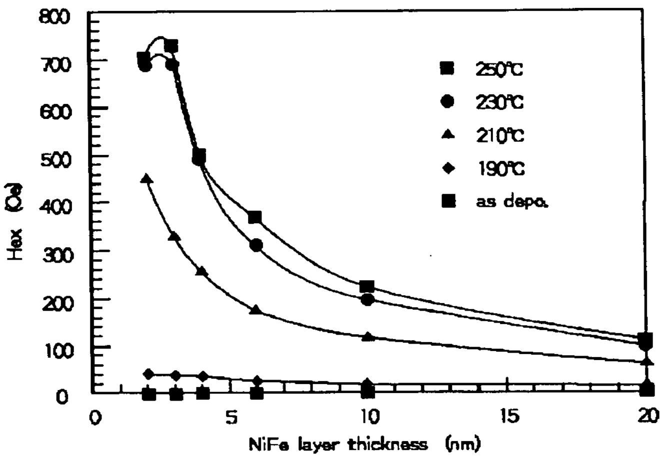
[Drawing 5]

図5



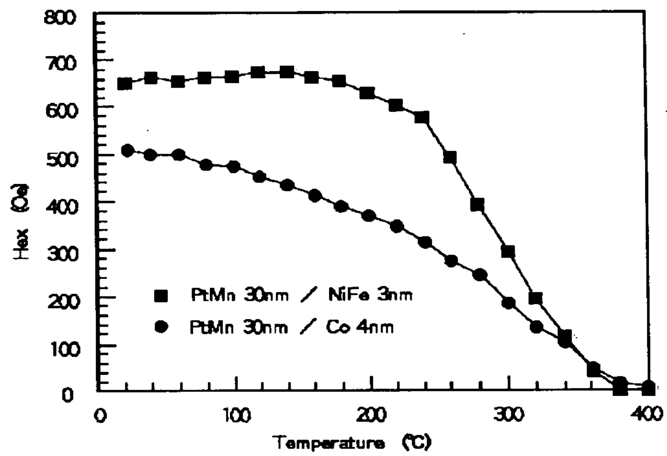
[Drawing 6]

図6



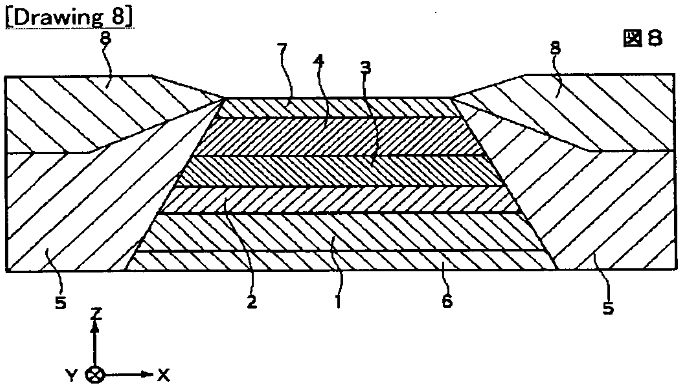
[Drawing 7]

図7



[Drawing 8]

図8



[Translation done.]